EVALUATING DEVELOPMENTS OF REGIONAL IMPACT USING TRANSIMS

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To my grandpa,

who always encouraged

me throughout my

thesis project.

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SUMMARY

The thesis develops and documents a workflow for applying TRANSIMS to the analysis of Developments of Regional Impact (DRI). The proposed workflow will consider perspectives of both the transportation agency responsible for the evaluating the DRI and the transportation engineer responsible for performing the analysis.

TRANSIMS offers a comprehensive framework for managing inputs and outputs that follow a transportation planning workflow. Not a single, monolithic software application, TRANSIMS is a suite of 65 small, light-weight, single-task tools for creating and manipulating GIS shape files and SQL data base files, estimating the elements of a four-step transportation modeling process, and computing link and vehicle delays for a given transportation network. Current analysis techniques for developments of regional impact require that the analyst apply arbitrary or non-repeatible estimates for trip assignments at the regional level. Because of the modular nature of the TRANSIMS, implementing each DRI as a layer in the GIS data base will permit the mixing and matching of multiple DRI within a local area, permitting a risk-based approach to the evaluation of multiple DRI, any of which may or may not actually happen.

This thesis focuses exclusively on the review of DRI analysis techniques, review of TRANSIMS modules, and development of a proposed DRI workflow within the TRANSIMS framework.

CHAPTER I

OVERVIEW

1.1 Developments of Regional Impact

A Development of Regional Impact (DRI), as the name implies, is a new development or an expansion of an existing development which is expected to not only have an impact on the local community, but on the region as a whole. Currently, the term DRI is unique to a few states and jurisdictions, including Florida, Georgia, Cape Cod, and Martha's Vineyard.

In Georgia, the Georgia Planning Act of 1989 gave the Department of Community Affairs (DCA) the power to create a methodology for the analysis of DRIs. In this methodology, new developments are judged by the Regional Commission to see if they meet the development thresholds set by the DCA. The size threshold is set by the type of the development as well as location of the development (whether or not it is a metropolitan region). The DRI review process is designed to increase the focus on quality growth, consider and plan for the impact on public infrastructure and services, and increase communication between localities, regions, and the state about new growth.[5]

The Georgia Regional Transportation Authority (GRTA) was formed in 1999 to combat air pollution, traffic congestion, and poorly planned development in the nonattainment area around metro Atlanta.[6] As such, when a DRI meets the thresholds set by the DCA in its jurisdiction, GRTA must approve the development. GRTA requires a detailed traffic analysis as the main submittal for their analysis.

1.2 TRANSIMS

TRANSIMS began at the Los Alamos National Laboratory as a new modeling tool for planning organizations. This computer model looks at both the individual interactions between vehicles and the overall effect on the network. After an initial development period, TRANSIMS switched from being a privately developed software into an open source software, which allows for individual users to customize TRANSIMS for their own use. The TRANSIMS software is built on a set of modules, which can be divided into a number of functions- network synthesis, population and activity generation, routing, and microsimulation. More details on individual modules are discussed in Chapter 3.

1.3 Summary

As the name implies, a DRI is the construction or expansion of a facility that is planned to have a large effect on a region, not just a local area. TRANSIMS is a regional traffic microsimulator, so it follows that TRANSIMS could be a powerful tool to analyze DRIs. The rest of this report investigates the use of TRANSIMS to analyze DRIs.

CHAPTER II

DEVELOPMENTS OF REGIONAL IMPACT

In this chapter, the reader is introduced to Developments of Regional Impact (DRI) and how they are evaluated in jurisdictions around the United States. The Georgia Regional Transportation Authority (GRTA) DRI evaluation process will be explored in greater detail. This section will highlight key differences and similarities across the various jurisdictions, and identify key steps to be accomplished within a technical analysis framework.

2.1 Developments of Regional Impact defined

A Development of Regional Impact is a new development or expansion of an existing development that is large enough to have a significant impact the resources of a region. The variety of projects that can fall under DRI status include large-scale planned developments, airport expansions, office and industrial parks, mining operations, and sports and entertainment facilities. The criteria for defining what is or is not a Development of Regional Impact can include project type, size (acreage, number of units or square feet of development), or proximity to other development or critical areas of concern and may vary from one jurisdiction to another. In Georgia, the Department of Community Affairs (DCA) provides size thresholds to gauge the impact of the development prior to construction, by type of development. The thresholds are set in order to identify impacts of the development on other developments, transportation infrastructure, water and stormwater, wetlands, and governmental services.[1]

2.2 Georgia DRI Process

While the Georgia DCA creates rules as to the analysis of DRIs, the responsibility for analyzing developments falls to the local government or Regional Commission that the development is located within. For the Atlanta metropolitan area, the Atlanta Regional Commission (ARC) is the leading agency for DRI's, and analyzes the DRI for its impact on a variety of resources and services in the region. However, the GRTA must also review and approve the development for developments in their jurisdiction, focusing solely on the impact of the development on the transportation infrastructure.

2.3 ARC DRI Traffic Analysis

The ARC DRI analysis evaluates the impact of the development on all forms of public infrastructure and services, including the transportation infrastructure. Developments are rated on whether or not the DRI transportation recommendations are consistent with the plans and studies that have been produced by ARC for the region's transportation such as the Regional Transportation Plan, Transportation Improvement Program, and Corridor Studies. ARC ensures that new developments consider the accessibility of the development to non-motorized travel and transit services. The ARC analysis also ensures that the development follows the access management guidelines for the area and has proper connections between developments.

2.4 The GRTA DRI Process

The GRTA DRI analysis focuses on the impact of traffic on the roadway infrastructure. GRTA publishes Technical Guidelines that outline what is expected in a DRI Transportation Analysis. Each transportation analysis must include an intersection analysis, and either a roadway segment analysis or a service volume threshold analyses.

Table 1: Intersection Level of Service Thresholds

Level of Service	Stop-Controlled Intersections Delay (s/veh)	Signalized Intersections Delay (s/veh)
A	0 - 10	0 - 10
B	> 10 - 15	> 10 - 20
C	> 15 - 25	> 20 - 35
D	> 25 - 35	> 35 - 55
E	> 35 - 50	> 55 - 80
F	> 50	> 80

2.4.1 Intersection analysis

An intersection analysis for the roadways surrounding a development determines how well traffic on all approaches of an intersection flow through the intersection. There are a variety of software packages that are utilized to model vehicles through intersections; however, they all are based on a set of formulas that are defined in the Highway Capacity Manual. The most common measures of intersection performance are the volume to capacity (v/c) ratio, delay, and Level of Service (LOS). The v/c ratio is calculated by dividing the demand volume by the capacity of the roadway. A low v/c ratio is desirable, and any value over one indicates severe congestion. Delay, measured in seconds, is the difference in travel time between uninterrupted free-flow through the intersection and actual time the average vehicle spends decelerating, queuing, accelerating, and crossing through the intersection. A small value for delay is desirable. In order to determine what is an acceptable delay, the Highway Capacity Manual (HCM) defines the LOS measurement through delay thresholds. LOS is measured on a scale from "A" to "F", and the delay thresholds vary between signalized and unsignalized intersections, as seen in Table 1.[7]

Unless the city and county that the DRI is located in have adopted alternate minimum standards, the LOS must remain at or above LOS D in urban areas and LOS C in rural areas. If the DRI is located in a Major Activity Center, LOS E is acceptable in urban areas and LOS D is acceptable in rural areas.

Table 2: Roadway Segment Level of Service Thresholds

Level of Service	Density (pc/mi/ln)
A	0 - 11
B	> 11 - 18
C	> 18 - 26
D	> 26 - 35
E	> 35 - 40
F	> 40

2.4.2 Roadway segment analysis

The roadway segment analysis focuses on vehicular flow between intersections. Similar to the intersection analysis, the performance measures used to characterize the functionality of segments is the LOS. The LOS for roadway segments is based off of the density of vehicles on the roadway, which can be converted to speeds, v/c ratios, and service flow rates with additional information on the roadway characteristics. The density threshold for each LOS is shown in Table 2.[7]

2.4.3 Service volume threshold analysis

Instead of a detailed roadway segment analysis, GRTA allows the use of the Florida Department of Transportation (FDOT) Service Volume Threshold tables. These tables base level of service on the annual average daily volumes of a segment, along with the roadway classification, number of lanes, and median type. If area-specific conditions are known, they may be used to modify the service volume threshold tables. This analysis only provides the daily level of service, not a peak hour analysis.[7]

2.4.4 Other GRTA technical guidelines

According to the GRTA Technical Guidelines, the DRI analysis must be a comprehensive analysis. As such, bicycle facilities and transit facilities must be included. The review must include the placement and details of any nearby existing facilities, along with any new onsite facilities, and how they connect. Both types of facilities, if justified, can be used to reduce off-site vehicle trips.[7]

In order to determine the number of new trips planned for the area, the Institute of Transportation Engineer's (ITE) Trip Generation Handbook should be used. While these values must be reported in the analysis, they can be reduced through mixed-use reductions (internal capture), alternative modes of transportation, and pass-by trips before analysis.[7]

Multiple methods of trip distribution are currently approved by GRTA. Distribution can be done via a Census Tract Analysis, Market Analysis, or TRANPLAN-Based Analysis. The Census Tract Analysis projects population and employment in the project area, and the percentage of the population/employment in the area is laid on a transportation map. The Market Analysis approach is used when analysis of target demographics for the site has already been completed, and those values can be applied to determine the traffic distribution. The third option is to use a TRANPLAN-Based Analysis. This analysis uses the model from the Regional Development Plan and Regional Transportation Plan to calculate the current traffic along the surrounding network in order to assign the project traffic.[7]

The study area for the DRI must include all roadway segments that the site has access to, extending in each direction to the nearest intersection with a major roadway. Segments must also be included if over 7% of the generated trips travel along the segment. Smaller networks can be approved ahead of time with approval from GRTA.[7]

2.4.5 Current Traffic Analysis Process

The steps necessary to complete a traffic analysis for GRTA, under current guidelines, is shown in Table 3.

Table 3: Current GRTA Analysis Methodology

Step	Current Method	Time Necessary to Complete Step
(1) Collect roadway geometry and characteristics	Take field measurements and/or measure from aerial photographs	Day(s)
(2) Collect traffic volumes and turning movement counts	Place count tubes on roadways and/or hand-count turning movements	Week(s)
(3) Create network in analysis software	Code network into analysis software	Day(s)
(4) Build exiting volumes to build-out year volumes	Multiply traffic counts by projected growth rate	Hour(s)
(5) Balance background traffic volumes	Ensure that volume into a segment is equal to volume out by hand	Day(s)
(6) Enter background volumes into analysis software	Code volumes into analysis software	Hour(s)
(7) Process no-build scenario	Completed during data entry	N/A
(8) Determine LOS of Intersections and Segments	Print reports containing performance measures	Minute(s)
(9) Create network with development infrastructure	Edit existing network to include additional infrastructure from the development	Hour(s)
(10) Project developmental traffic volumes	Use the ITE Trip Generation Handbook	Hour(s)
(11) Add development volumes to background traffic	Add development traffic to the background traffic in model	Hour(s)
(12) Process build scenario	Completed during data entry	N/A
(13) Determine LOS of Intersections and Segments	Print reports containing performance measures	Minute(s)

Continued on next page

Table 3 – continued from previous page

Step	Current Method	Time Necessary to Complete Step
(14) Make network changes to mitigate losses in performance	Edit network elements in analysis software	Minutes(s)
(15) Process Improvements Scenario	Completed during data entry	N/A
(16) Determine LOS of Intersections and Segments	Print reports conataining HSM performance measures	Minute(s)
(17) Repeat Steps 14-16 until all losses are mitigated	See other steps	Hour(s)

2.5 Comparison with Other Jurisdictions

While only a few jurisdictions have a DRI process that evaluates the impact of a development on traffic and other utilities, many jurisdictions have a process in place to analyze the impact of a development on only the traffic in the area, referred to as a Traffic Impact Analysis (TIA) or Traffic Impact Study (TIS). While there are some differences between regions, the fundamental process is the same. In this section, the DRI process for the Georgia DCA/GRTA is compared to the DRI/TIA/TIS process for the following jurisdictions:

- Florida Department of Community Affairs (Florida DCA)
- Cape Cod Commission (CCC)
- California Department of Transportation (CalTrans)
- Indiana Department of Transportation (INDOT)
- Idaho Transportation Department (ITD)
- Sedro-Wooley, Washington

- Bowling Green, Kentucky

- Huntersville, North Carolina

2.5.1 Analysis Thresholds

The largest difference between a DRI Traffic Analysis and a TIA or TIS is in the thresholds. Due to the broader scope of a DRI, the thresholds that require a DRI analysis are based primarily on the type of development and the capacity of the development, not the number of trips generated. Table 4 shows the difference between the DRI Thresholds for the Georgia DCA, the CCC, and the Florida DCA.[7][14][2] The more common land uses, such as office, commercial, wholesale & distribution, housing, industrial, mixed use, and attractions & recreational facilities, have a threshold in all jurisdictions. The minimum thresholds value for the Georgia DCA and Florida DCA are very similar, while CCC's thresholds are a lot less. The difference in threshold values is due to the fact that the Georgia DCA and Florida DCA are trying to manage the growth of larger regions, while the focus of the CCC is to protect the natural resources of a small area. It should also be noted that the jurisdictions have a few unique land uses that are of concern to the region. Georgia DCA is very concerned with water supply intakes and reservoirs as Georgia's water supply comes mainly from rivers, while Florida has a high water table and springs to draw from. Likewise, the CCC is concerned with historic structures, new transportation facilities into the region, and new roadways to water bodies in order to preserve the history and environment of the area, none of which are priorities in Georgia or Florida.

Table 4: Comparison of DRI Thresholds

Type of development	Georgia Developments of Regional Impact		Florida Department of Community Affairs	Cape Cod Commission
	Metropolitan Regions	Non-metropolitan Regions		
Office	400,000+ sq ft	125,000+ sq ft	30+ acres or 300,000+ sq ft	10,000+ sq ft
Commercial	300,000+ sq ft	175,000+ sq ft	40+ acres, 400,000+ sq ft, or 2,500+ parking spots	10,000+ sq ft
Wholesale and Distribution	500,000+ sq ft	175,000+ sq ft	40+ acres, 400,000+ sq ft, or 2,500+ parking spots	10,000+ sq ft
Hospitals and Health Care Facilities	300+ new beds or 375+ pk hr trips	200+ new beds or 250+ pk hr trips	350+ units, or 750+ units (county population over 500,000)	N/A
Housing	400+ new lots	125+ new lots	Based on county population	30+ acres or 30+ lots
Industrial	500,000+ sq ft, 1,600+ workers, or 400+ acres	175,000+ sq ft, 500+ workers, or 125+ acres	1,500+ parking spots or ¿1 sq mile	10,000+ sq ft
Hotels	400+ rooms	250+ rooms	600+ beds or serve multiple counties	N/A
Mixed Use	400,000+ sq ft or 120+ acres	125,000+ sq ft or 40+ acres	Based on combination of other thresholds	20,000+ sq ft
Airports	All new airports, runways and runway extensions	Any new airport with a paved runway; or runway additions of more than 25% of existing runway length	All new airports, runways and runway extensions	N/A

Table 4 – continued from previous page

Type of development	Georgia Developments of Regional Impact		Florida Department of Community Affairs	Cape Cod Commission
	Metropolitan Regions	Non-metropolitan Regions		
Attractions and Recreational Facilities	1,500+ parking spaces or capacity of 6,000+		Single-Performance: 2,500+ parking spaces or 10,000+ seats; Multiple Performances (a day): 1,000+ parking spaces or 4,000+ seats	New construction or changes to properties with 40,000+ sq ft
Post-Secondary School	New school with 2,400+ students, or 25%+ expansion		3,000+ students, or 20%+ expansion	N/A
Waste Handling Facilities	New facility or 50%+ expansion		N/A	N/A
Quarries, Asphalt, and Cement Plants	New facility or 50%+ expansion		N/A	N/A
Wastewater Treatment Facilities	New major facility, 50%+ expansion, or 150,000+ gallons per day		N/A	N/A
Petroleum Storage Facility	50,000+ barrels if within 1,000 ft of water supply; otherwise, 200,000+ barrels			N/A
Water Supply Intakes/Reservoirs	New Facilities		N/A	N/A
Intermodal Terminals	New Facilities		N/A	N/A
Truck Stops	3+ diesel pumps, 1/2+ acre of truck parking, or 10+ truck parking spaces		N/A	N/A
Any other development types not identified above (includes parking facilities)	1000+ parking spaces or 5,000+ daily trips generated		N/A	N/A

Table 4 – continued from previous page

Type of development	Georgia Developments of Regional Impact		Florida Department of Community Affairs	Cape Cod Commission
	Metropolitan Regions	Non-metropolitan Regions		
Electrical Generating Facilities and Transmission Lines	N/A	100+ megawatt steam generating facility or 230+ kilovolt inter-county transmission line	N/A	N/A
Mining	N/A	N/A	100+ acres using 3,000,000+ gallons water per day	N/A
Port Facilities	N/A	N/A	All commercial ports, or 100+ sport/pleasure watercraft	N/A
Transportation Facilities to/from Region	N/A	N/A	N/A	Any facility
Historic Structure	N/A	N/A	N/A	Any demolition or change
Road Construction	N/A	N/A	N/A	Provides access to water bodies or wetlands
Towers	N/A	N/A	N/A	35+ ft tall

Instead of setting analysis thresholds by land use, the jurisdictions that only have TIA/TIS processes set thresholds based on trips generated, as seen in Table 5.[3][11][12][13][15] CalTrans, INDOT, ITD, and Bowling Green set a base of 100 or more peak hour trips to trigger a TIA/TIS, while Sedro-Wooley and Huntersville have a smaller threshold of 50 or more peak hour trips. All three cities have a minimum of 500 total trips per day to trigger a TIA/TIS.

Table 5: Comparison of TIA/TIS Thresholds

Jurisdiction	Peak Hour Trips	Daily Trips	Other Criteria
California Department of Transportation	LOS A/B: 100+ Trips LOS C/D: 50-100 Trips LOS E/F: 1-49 Trips	N/A	N/A
Indiana Department of Transportation	100+ Trips	N/A	Causes LOS C or worse at adjacent intersections, Other intersections already LOS D or worse
Idaho Transportation Department	Full Study: 100+ Trips Minor Study: 25-99 Trips	Full Study: 1000+ Trips Minor Study: 250-999 Trips	N/A N/A
Sedro-Wooley, Washington	50+ Trips	500+ Trips	Expansion of Existing Project
Bowling Green, Kentucky	100+ Trips	500+ Trips	Near sensitive area, high accident location, or highly congested area
Huntersville, North Carolina	50+ Trips	500+ Trips	N/A

2.5.2 Project Boundaries

For most jurisdictions, prior to the DRI, TIA, or TIS, a pre-application meeting is held to review the methodology for the analysis. It is during this review that the boundaries for the project are decided. All jurisdictions make determinations on the project boundaries based on the specific site layout, but most jurisdictions also have a guideline as to the necessary area. The individual requirements can be seen in Table 6, but for the most part, the study network should extend from the development to the nearest intersection with a major roadway that is a part of the regional roadway system.[2][3][7][11][12][13][14][15] All of the site access points are also required to be in the study area. For GDCA and ITD, any link where trips to and from the DRI exceed 7% and 5%, respectively, of the total two-way daily volume of the link, must be included in the study area.

2.5.3 Project Description

All of the jurisdictions require location maps, site plans, land uses, and a description of the access points. Most of the jurisdictions also require a list of any other developments/transportation projects in the area, the phasing of the project, and the bicycle, pedestrian, and transit facilities in the area. How the project fits with the Local Government's Comprehensive Plan is a unique element to the jurisdictions that are doing a DRI process and not just a TIA/TIS.

2.5.4 Trip Generation

The ITE Trip Generation Handbook can be used in all jurisdictions in order to determine the number of trips generated by the development. The Florida DCA and INDOT allow local standards and data to be used to generate trips instead of the ITE Handbook. Internal capture, mode split, and pass-by trips are permitted to be used to reduce the number of trips. Pass-by trips are limited to 10-25% of the adjacent roadway volume for GRTA, CCC, CalTrans, and Huntersville. All trip reductions

Table 6: Traffic Study Boundaries

Jurisdiction	DRI/TIA/TIS Boundaries
Georgia Regional Transportation Authority	All access points, extending to the nearest intersection with a major roadway. Any other segments where trips from the DRI exceed 7% of the two-way daily service volume.
Florida Department of Community Affairs	Not specified
Cape Cod Commission	Must include all regional roadway links and intersections
Caltrans	State highway facilities meeting threshold, and local facilities upstream and downstream
Indiana Department of Transportation	All site access points and major intersections adjacent to site. First signalized intersection on street serving the site if within 1/2 mile or one cycle length of travel time.
Idaho Transportation Department	Links that experience directional increase of 250 ADT or 25 veh in peak hour, extending up to 1/2 mile, include any street that experiences 5% directional increase. Minimum of entire frontage + access spacing distance (or nearest intersecting collector)
Sedro-Wooley, Washington	Determined by City's Engineer and Planner
Bowling Green, Kentucky	Not specified
Huntersville, North Carolina	Not specified

must be approved in the preconference meeting with the jurisdiction.

2.5.5 Analysis Methods

In most jurisdictions, the method of Trip Generation is up to the analyst, but must be approved at the preapplication meeting. GRTA provides three options to distribute trips: a Census Tract Analysis, Market Analysis, or TRANPLAN Regional model. Bowling Green also provides guidance, allowing a gravity model or other locally accepted model to be used in order to distribute trips.

In order to calculate the future no-build traffic, the main method used is to look at historic traffic growth patterns, and use the historic growth pattern to predict future traffic.

2.6 Summary

Traffic analysis of potential new developments is a concept that has been implemented in place in many regions around the United States. By analyzing traffic impacts on the region, the roadway network can be updated so that it is able to handle the demands of the new development. The technical guidelines for DRIs in Georgia require a minimum level of service and maximum v/c ratio for the roadway network surrounding the DRI. The traffic analysis methodology at use in Georgia is very similar to the methodologies used in other jurisdictions around the United States.

CHAPTER III

TRANSIMS

In this chapter, the TRANSIMS transportation analysis framework and software is presented. Key modules supporting the analysis of a Development of Regional Impact (DRI) are identified and discussed in greater detail.

3.1 Overview of TRANSIMS

The TRANSIMS framework provides tools to convert and create roadway networks, translate back and forth between GIS shapefiles and text data files; visualize model outputs; manipulate trip tables; extract subarea networks for more detailed analysis; summarize vehicle trajectory profiles to link, intersection and route performance measures; and, compare changes in performance measures between two consecutive iterations and control the feedback process.

To run TRANSIMS, the user typically builds batch files, shell scripts or perl scripts to run the executables in a pre-determined order. Each executable reads settings from a text control file that describes input and output files and other settings.

Application of TRANSIMS is very flexible, but very difficult to kick-start. Because each tool generally performs only one function, the user is afforded tremendous flexibility to pick and choose the order that the tools are applied. This flexibility comes at a high price, the user is required to have a good working knowledge of what each tool can do - with over 65 individual tools, the initial learning curve is quite steep. Supporting the entire suite of executables is a family of GIS shape files and data base files. All the primary inputs including transportation network, households, agenda, trip tables, trip plans, volumes, delays, other model outputs are stored directly in GIS shape files. All the executables have access to these data files as necessary, and can read and write their data directly to different layers.

3.2 TRANSIMS tools

TRANSIMS tools are grouped into several families of tools that perform complementary functions. The purpose of describing these tools is to provide an overview of the modeling process and the relationships between inputs and outputs of each model. Each tool is designed to completely decoupled from the others, easily replaceable with alternate (new and improved) tools. The inputs and outputs of each tool are clearly defined, further promoting the pluggable nature of the framework.

3.2.1 Main Modules

At the core, TRANSIMS is a four-step transportation modeling tool. While TRANSIMS can utilize traditional trip tables, the model was originally developed to support an activity- and household-based approach. In any case, each of these steps is performed by a single executable. These executables are stored in the ./Bin directory.

PopSyn.exe - generates a synthetic population for a region. This population is represented by individual travelers organized into households. PopSyn ensures that the demographic data of these synthetic households closely matches Census block group and tract data for the region under study. Each household is assigned demographic data (number of individuals, ages, etc.), a location on the network, and one or more vehicles.

ActGen.exe - for each individual in each household in the region, ActGen produces a set of desired activities. When available, these activities are constrained such that they match observed household activity data. An activity is described by a desired begin time, end time, network location and mode of travel.

Router.exe - for each activity, the router assigns an initial start time, desired link-by-link travel path, and estimated arrival time. Collectively, these individual trips are gathered into a Plan file and stored within the GIS. The router uses a modified

Dijkstra's algorithm to assign vehicles to a route with a minimum travel time.

Microsimulator.exe - once the trips have been assigned to the network, the Microsimulator simulates the second-by-second movement and interactions of the individual vehicles as they execute their prescribed travel plans. The vehicles interact with each other and with the traffic control system. Individual vehicle trajectories are stored, and using subsequent tools, these trajectories can be mined to produce link, intersection, route, and subregion aggregate measures of performance.

In most cases, the estimates of link travel times used by Router.exe to determine the initial traffic assignments differ from the travel times determined by the microsimulator. Subsequent TRANSIMS tools compares differences in these link travel times, identifies subsets of all trips whose routes must be recomputed, and assigns new travel time estimates to links, and sets up to rerun the Router.

This process of revising link travel time estimates, identifying trips that must be rerouted, and rerouting the trips is one example of a feedback loop within TRANSIMS.

TRANSIMS provides tools for monitoring differences in estimated and simulated travel times (PlanCompare.exe), selecting households for rerouting based on V/C or other criteria (PlanSelect.exe), and based on problem criteria (ProblemSelect.exe).

The Microsimulator produces vehicle trajectories. TRANSIMS provides tools for aggregating these individual vehicle trajectories into volumes, turning counts, link densities, link queues, and average travel times for each link in the system (LinkSum.exe), and for visualizing the movement 2-D movement of the vehicles through the network (ArcSnapshot.exe.)

The Microsimulator is very expensive (time consuming) to run. Especially in congested networks, a significant number of traffic assignment-simulation iterations are necessary for the process to converge. To streamline the process and permit earlier iterations to be performed more cheaply, PlanSum.exe is often substituted for the Microsimulator.exe. PlanSum estimates link travel times using a BPR approach.

On a side note - many in the traffic modeling community have expressed concern about the fidelity and validity of the Microsimulator in TRANSIMS. Because of the pluggable nature of the environment, it would be relatively simple to craft a more acceptable, vehicle-following microsimulator. Rather than competing with the existing tool, this new microsimulator would complement the existing suite of tools by providing the "micro" model to work with the "meso" and "macro" models already in TRANSIMS.

3.2.2 Roadway network tools

To support the creation and management of the complex roadway network files required for TRANSIMS, a number of tools were created. TransimsNet.exe builds a refined TRANSIMS network from a simple node table, link table and zone centroid table. IntControl.exe assigns traffic control devices and develops signal control plans for the draft network.

3.2.3 GIS tools

A suite of GIS tools have been developed to help visualize various aspects of the input and output data. ArcNet.exe creates GIS Shape files from the files created by the roadway network tools describe above. ArcPlan.exe displays individual travel plans produced by Router.exe during the traffic assignment step. To help the user debug potential issues in the traffic network, ArcProblem.exe identifies zero-node problems, access issues, circuitry problems, and others identified during traffic assignment in Router.exe

After running the Microsimulator, ArcDelay.exe permits the user to visualize link delays, volumes, and other modeling artifacts by creating new layers in the GIS.

If the user receives already-created GIS shapefiles, GISNet.exe can be used to convert them into standard TRANSIMS network files. These input files may then be used as input to regular data coding process.

3.2.4 Other tools

As mentioned earlier, TRANSIMS consists of 65 tools for working with the inputs and outputs of each of the major steps in the transportation modeling process. The reader is directed to the References section to find out where to learn more. The developers of TRANSIMS have also developed a template tool, that is, a tool that contains sets up all the necessary overhead code to read control files and manipulate the GIS data bases. This "just-add-water" approach permits the easy creation of new tools for the TRANSIMS suite.

3.3 DRI-related TRANSIMS modules

In the next sections, equivalent TRANSIMS modules will be identified and discussed. Figure 1 shows the modules used to complete a traffic analysis within TRANSIMS, from network creation to final traffic analysis.

3.3.1 Network Modules

The network modules are used to create a TRANSIMS network that contains all of the roadways in a region. The TRANSIMS network must be very detailed in order to accurately model traveler behavior- including not only the locations of roadway segments, but also the roadway characteristics (number of lanes, speed limit, turn-bays, etc), traffic signal information, and information on the available public transportation in the region. The network modules help create the TRANSIMS network by creating TRANSIMS files for network elements from basic inputs about the links.

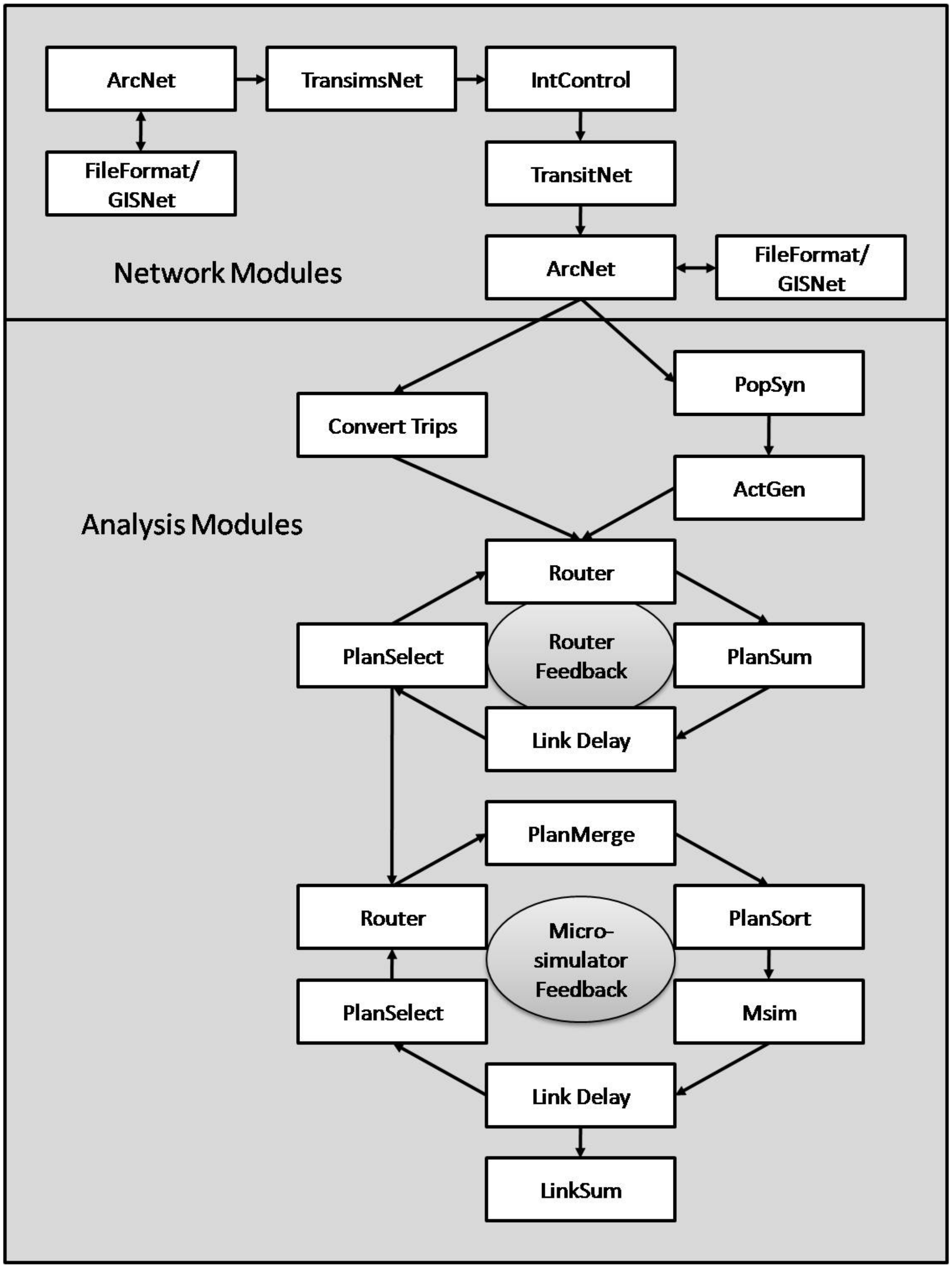

Figure 1: TRANSIMS Flowchart

3.3.1.1 TransimsNet

TransimsNet is the module that creates network files. From the information provided in input link, node, shape, and zone files, TransimsNet outputs TRANSIMS files for links, nodes, zones, pocket lanes (turn lanes), lane connectivity, parking locations, activity locations, and process links (dummy links connecting parking and activity locations). The information for links, nodes, zones, pocket lanes, and lane connectivity is found in the input files, while TRANSIMS places activity locations, parking locations, and process links evenly along every link. TransimsNet creates sign and signal warrants for the roadways as well. The inputs for TransimsNet are generally created outside of the TRANSIMS framework, and the network files that are output are used in almost all future modules.

3.3.1.2 IntControl

From the sign and signal warrants created by TransimsNet, IntControl creates traffic control files for the network. The unsignalized node file records the position of yield and stop signs, while information on traffic signals is found in the signalized node, phasing plan, timing plan, and detector files. Parameters for the traffic signals are defined in the control file for IntControl. Parameters can be set by time period, but they apply to all signals in the network. The network files from IntControl combine with those created in TransimsNet and provide the network information for future modules.

3.3.1.3 ArcNet, FileFormat, and GISNet

At any point during network creation, ArcNet can be run to create shape files of any and all of the network files. The shape files can be opened with geographic information system (GIS) software and edited as needed to clean up the network that was created through TRANSIMS. Two programs are available to convert shape files back into transims network files, FileFormat and GISNet. If there are shape files available for a network, these modules can be used to create TRANSIMS network files instead of using the TransimsNet, IntControl, and TransitNet modules to create them.

3.3.1.4 TransitNet

For networks that include transit, TransitNet is available to create the transit network in TRANSIMS. TransitNet takes the network files created by TransimsNet along with information about routes, park and ride lots, and fares. This module creates updated parking, activity location, and process link files, as well as new transit stops, routes, schedules, and driver files. The control file contains parameters such as the spacing of transit stops, the time period that transit runs, and the minimum dwell time at each stop. The network files created by TransitNet are combined with the previous network files to form the network information that is input into most future modules.

3.3.2 Analysis Modules

The analysis modules create trips, place them on the network, and simulate vehicle interactions in order to determine the performance of links along the network.

3.3.2.1 ConvertTrips

One of the methods of creating a sample population and assigning trips to the population is through the use of a trip-based model. Trip tables (input text files listing the number of trips between zones) and the network files are input into ConvertTrips to create trip plans for a population. ConvertTrips accepts multiple trip tables, for varying trip purposes and distributions of trips over the day. A separate person and vehicle is created for each trip, with an origin and destination activity location chosen from the provided origin and destination zones. The time assigned for each trip is the goal of when the individuals want to leave their origin and arrive at their destination, and does not include the actual travel time with other traffic on the roadway. The trip file from ConvertTrips is input into the Router.

3.3.2.2 PopSyn and ActGen

A tour-based model is another methodology used to create a population and assign trips to the population, using census data and trip surveys instead of trip tables. It requires more intensive data than trip tables, including travel surveys that encompass a wide range of socioeconomic factors in order to have a true idea of how people travel.

The census data necessary for a TRANSIMS analysis can be downloaded from the US Census Bureau website. However, complete census data is only available every 10 years, so the census data is often not as current as the trip tables. There are currently TRANSIMS modules under development to help convert the census data from the census website to files that TRANSIMS can read and interpret.

PopSyn is used to generate a synthetic population from census data. PopSyn creates individual travelers and groups the travelers into households based on census data and the probability of household types in a certain region. The population synthesizer is also responsible for identifying the number of vehicles available in each household and assigning them to the parking lot associated with the activity location that it sets as home for the household.

Once the synthetic population is created, ActGen matches each household with a surveyed household that has similar socioeconomic conditions in order to determine the travel patterns for the household. The output of the activity generator is the same as the output of ConvertTrips in the trip-based model, as it is a list of origins, destinations, and trip times for each traveler. This file also includes information on the transportation method that should be utilized for the trip. The trip file is then input into the Router.

3.3.2.3 Router

The Router inputs the trip file and network files to determines the best route for each of the travelers. When assigning routes, each route is created separately of other routes. The first time Router is run, there is no information about traffic conditions, and trips are assigned based on the shortest time route. After the first run, the congestion resulting from other vehicles on the roadway can be input into Router in order for certain links to become less appealing to travelers. The output of the router is a trip file which lists the nodes and links that each and every vehicle travels through during every trip.

3.3.2.4 PlanSum

PlanSum is used to estimate link delays based on the results from the router. Instead of looking at how vehicles interact, PlanSum reads the plans and counts the average number of vehicles on each link during a 15-minute period. This often leads to volumes and v/c ratios on links that greatly exceed capacity because the router only processes one trip at a time and does not keep track of the positions of other vehicles. PlanSum is also able to output data on Ridership, link volumes, and trip tables.

3.3.2.5 MicroSimulator

The Microsimulator takes the trips records and simulates individual vehicle movements and their interaction with other vehicles, but does not change the predetermined route of the vehicle. The Microsimulator places each vehicle on the network at the prescribed time, but vehicles can only move as fast as traffic allows. From the simulation, a snapshot file is created that lists where each vehicle is at every second during the day. A performance file is also created which includes information on how the network is performing during the day.

3.3.2.6 LinkDelay

The LinkDelay module takes the performance file given by either PlanSum or the Microsimulator and averages the delay on links between router runs to give a better estimate of the delay than any one run can provide.

3.3.2.7 PlanCompare

PlanCompare creates a list of trips that are different between two iterations of the trip files. Two sets of trip plans are input into PlanCompare, which compares them record by record in order to create a list of edited plans. The control file contains parameters to only look for plans whose travel times changed by more than a certain percent, and limits the number of selected plans, so that each iteration does not change every record.

3.3.2.8 PlanMerge

PlanMerge is a fairly simple module that takes the trip list from PlanCompare and combines them with the previous set of plans. This is done in order to update the records of the plans with the results of a run.

3.3.2.9 PlanPrep

PlanPrep is a module that sorts the plans for input into a different module. Plans can either be sorted by traveler number or the travel time. When the plan file comes out of PlanMerge, it is sorted by traveler number. However, the router reads the plans in the order of the file, so the plans need to be sorted by travel time before input into the Router.

3.3.2.10 PlanSelect

The module called PlanSelect is used to select a portion of the plan files by parameters set in a control file. With a minimum v/c ratio, a plan is only selected if any of the links the traveler uses exceeds the v/c ratio. There is also a time of day range, so that records can be selected during important time periods. If there is a smaller region of interest, plans can be selected if they pass through certain links or nodes during their route. There is also an option to select plans that differ from their original travel time by a certain percent.

3.3.2.11 LinkSum

LinkSum is the final module used in the analysis of a network. It takes the performance file from the Microsimulator and summarizes it by link. The program can output separate files for variables such as link volumes, speeds, volume-to-capacity (v/c) ratios, travel times, and link time ratios. Reports can also be generated as to the top 100 of any of the variables.

3.4 Feedback Loops

A single run of the router and microsimulator does not accurately predict traffic volumes and delays, as it does not account for drivers who will choose alternate routes if their theoretical shortest-time route is congested. In order for TRANSIMS to correctly simulate traffic and congestion, the system must come to equilibrium through iterations of various modules. There are three feedback loops that can be utilized to help the model converge: router feedback, microsimulator feedback, and user equilibrium.

3.4.1 Router Feedback Loop

A router feedback loop allows the network to begin to converge without running the microsimulator. The router feedback loop uses PlanSum to estimate the delay on the links from the Router's trip file, saving a considerable length of time as compared to running the Microsimulator. Before the next iteration of the router, PlanSelect chooses a portion of the files to reroute. When the router is run again, it uses the link delays given by PlanSum to reroute a subset of the vehicles, with the knowledge of where existing congestion is located.

3.4.2 Microsimulator Feedback Loop

The microsimulator feedback loop is similar to the router feedback loop, but instead of using PlanSum to estimate the delay on links, the microsimulator is run. The microsimulator gives more accurate results for the delay on links. A percentage of the plans are selected to be rerouted using PlanSelect, and then the process repeats with the Router and Microsimulator. With PlanSelect, the loop can be focused on certain congested time periods and minimizing the travelers whose trip duration is significantly different from the path travel time.

3.4.3 User Equilibrium Loop

The last loop, the user equilibrium loop, is the reverse of the microsimulator loop. Within this loop, the microsimulator is run to provide link delays to router, and the goal is to minimize the number of vehicles that can find a better route. PlanCompare is used to measure the difference between the previous plans and new plans, and any significantly different plans (up to 2% of total trips) are replaced for resimulation.

3.5 Summary

TRANSIMS is a powerful microsimulating tool. It is made of multiple modules that each run a specific portion of the model. This feature allows TRANSIMS to be customized for each application. TRANSIMS includes modules to create a network, distribute trips, route trips, and simulate vehicles on the network. It is important to utilize the feedback loops to reach vehicle equilibrium. Batch files specify when each control file is run, and can be customized to run in the order and combination that each model requires.

CHAPTER IV

PROPOSED FRAMEWORK

In this section, the current methodology for completing the DRI traffic analysis will be discussed, and a methodology for completing the DRI traffic analysis in TRANSIMS will be presented.

4.1 Summary of current practice

As described in chapter 2, pre-development analysis of the impact of traffic that is expected to be generated by new development on existing roadway networks is a concept that has been implemented in many regions around the United States. Analyzing the new development traffic impacts on a regional road network helps to identify potential network deficiencies and provides an opportunity to address those deficiencies before the traffic is placed on the roadway network.

In current practice, when a new development requires a DRI and/or traffic impact analysis, roadway geometry, traffic volumes, and turning movement counts are collected for the area surrounding the DRI. The background volumes are grown to the build-out year. The no-build level of service is found by inputting the background volumes onto the current roadway geometry in a traffic analysis software such as Synchro. The ITE Trip Generation Handbook is used to project the new site traffic volumes for the build-out level of service determination, using the size and type of development. Assumptions as to which segments the new trips utilize when traveling to and from the site are based on current traffic patterns and/or population distributions near the DRI. The site traffic is combined with the background traffic to provide the build-out traffic volume. The build-out traffic is placed onto the base network to determine level of service of the area after the development.

Based on the differences between the no-build and build-out level of service, the developer must suggest improvements to the roadway wherever the development worsens the level of service. These suggestions are also modeled in the traffic analysis software to ensure that the improvements return the facility to an acceptable level of service.

In order to determine the best practice for evaluating Developments of Regional Impact (DRI) in TRANSIMS, a sample development was created to be implemented into an existing transportation network.

4.2 Overview of TRANSIMS Methodology

The same general steps used in current practice for traffic analysis are applied using TRANSIMS, as shown in Table 7

Table 7: Methodology to Complete Traffic Study within TRANSIMS

Step	TRANSIMS Method	Time Necessary to Complete Step
(1) Collect roadway geometry and characteristics	Take field measurements and/or measure from aerial photographs	Day(s)
(2) Collect traffic volumes and turning movement counts	Already exists in regional TRANSIMS network	N/A
(3) Create network in analysis software	Run network modules and ensure that existing TRANSIMS network matches field observations	Hour(s)
(4) Build exiting volumes to build-out year volumes	Add growth factors to ConvertTrips control files	Minutes(s)
(5) Balance background traffic volumes	Not applicable to TRANSIMS	N/A
(6) Enter background volumes into analysis software	Already in exists in regional Trip Tables	N/A
(7) Process no-build scenario	Run analysis modules	Hour(s)

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Table 7 – continued from previous page

Step	TRANSIMS Method	Time Necessary to Complete Step
(8) Determine LOS of Intersections and Segments	Convert results from analysis modules into level of service performance measures	Hour(s)
(9) Create network with development infrastructure	Edit TRANSIMS network to include DRI infrastructure	Hour(s)
(10) Project developmental traffic volumes	Use the ITE Trip Generation Handbook	Hour(s)
(11) Add development volumes to background traffic	Add development volumes into trip tables	Hour(s)
(12) Process build scenario	Run analysis modules	Hour(s)
(13) Determine LOS of Intersections and Segments	Convert results from analysis modules into level of service performance measures	Hour(s)
(14) Make network changes to mitigate losses in performance	Edit network elements in analysis software	Hour(s)
(15) Process Improvements Scenario	Run analysis modules	Hour(s)
(16) Determine LOS of Intersections and Segments	Convert results from analysis modules into level of service performance measures	Hour(s)
(17) Repeat Steps 14-16 until all losses are mitigated	See other steps	Day(s)

4.3 Assumptions

The proposed TRANSIMS methodology makes a few assumptions about the TRANSIMS network and the analyst.

1. A basic set of control files and batch files exists to run the network.
2. The analyst understands how to run individual modules.
3. The analyst has a working knowledge of a GIS software package.

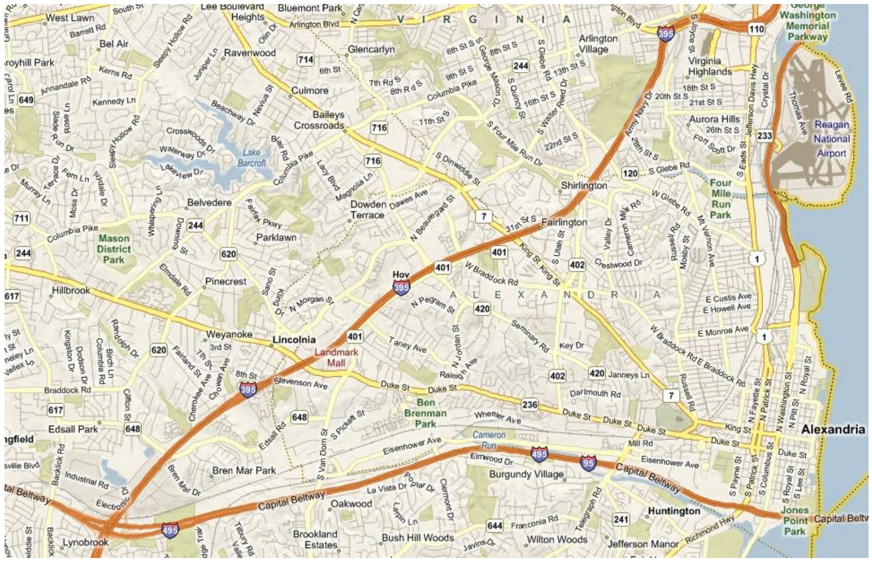

Figure 2: Overview of Alexandria, Virginia, Source: Bing, Microsoft 2009

4. The TRANSIMS network is complete, functional, and accepted as an accurate regional model.

Originally, the Atlanta, Georgia metro area was going to be used for this case study. The existing Atlanta TRANSIMS model includes network files and trips tables, but no control files or batch files. A set of control and batch files were created for the network files and the proposed DRI was set up in the model. It was later determined that the Atlanta TRANSIMS model had issues which prevented the proper evaluation of the study in a timely manner. After considerable effort to debug the problems, a decision was made to utilize the Alexandria, Virginia TRANSIMS model. The Alexandria network is provided with the TRANSIMS release as a test case. As it was designed to provide an introduction to TRANSIMS, it is a fairly simple TRANSIMS network, and contains all the control and batch files needed to run the network. The network is mostly contained between I-395, I-95/495, and the Potomac River, as seen in Figure 2.

This network was chosen due to its size, and existing batch and control files. It demonstrates a region much larger than is currently analyzed for DRIs, but is still small enough that 5 router loops and 5 microsimulator loops can be completed in less than two hours on a personal computer. It also contains the diversity found in large regions, a downtown area with a very structured road network, more residential areas with a more random road network, a transit network, and interstates. However, the city is mainly residential, with commercial zoning found sprinkled throughout.

In order to focus on the DRI analysis itself, a few assumptions were made about the Alexandria network.

1. The Alexandria network was assumed to be complete and all roadway characteristics correct.
2. The traffic volumes presented by way of trip tables was assumed to be representative of current traffic patterns.
3. There are no other developments scheduled to be added to the roadway network between the present year and build-out year.

4.4 Preliminary Network Creation

As stated before, this methodology assumes that the regional network is complete, and development-related changes will be the only network edits necessary. The network should be opened in a GIS software to examine the network surrounding the site of the DRI. For the most part, regional network creation is completed by starting with the basic network elements (such as link, node, pocket lanes, and lane connectivity files), and letting TRANSIMS make assumptions as to the finer details of the network (signal timings, activity locations, etc.) Thus, the first step in a DRI analysis is checking the TRANSIMS network around the DRI to ensure that it reflects actual conditions. Due to the methods that TRANSIMS uses to place activity locations, there are activity locations regularly spaced on every link. The area of land that is being developed in the DRI needs to be cleared of all activity locations, and activity locations need to be

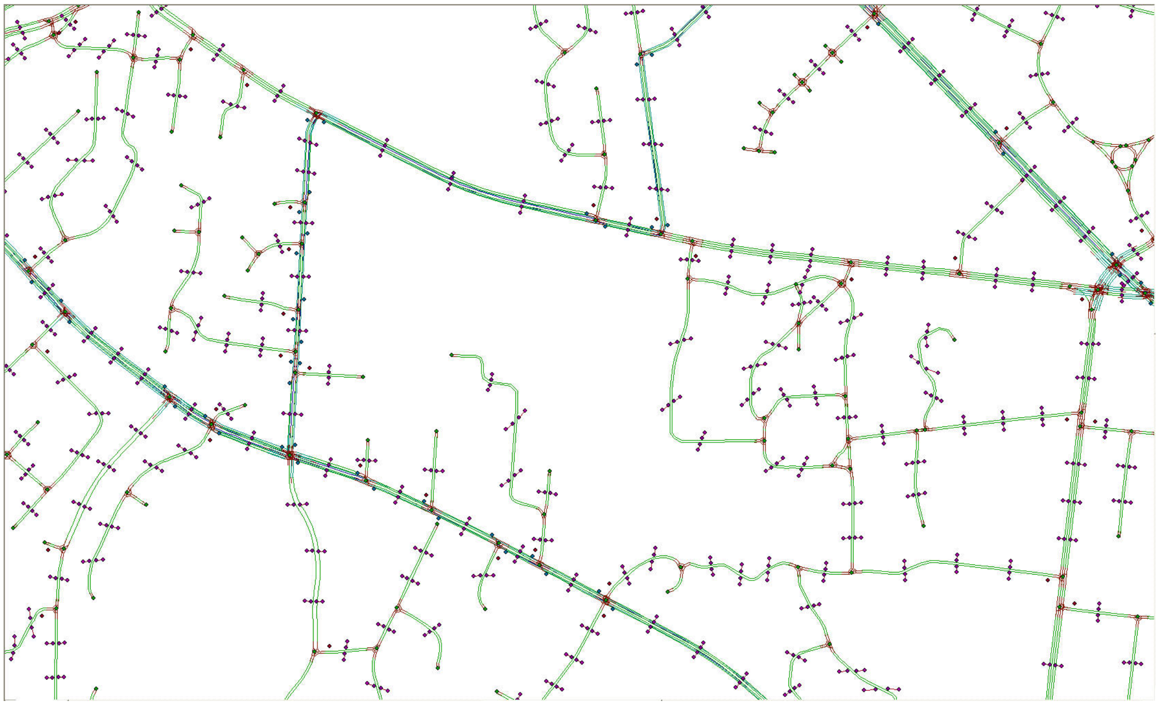

Figure 3: Existing TRANSIMS No-Build Network

placed on the links surrounding the DRI to correspond with existing driveways near the DRI location.

As part of the network editing, any planned improvements that will be completed prior to the build-out year should be added to the network as well. Once the network is correct in the GIS program, either FileFormat or GISNet should be used to convert the shape files back to TRANSIMS files.

Two networks were created- one for use with the no-build scenario, and one for use with the build scenario.

The given Alexandria network is shown in Figure 3. For the no-build scenario, the original network was processed through TransimsNet, IntControl, TransitNet, and then ArcNet. The files were opened with a GIS editor, and any activity locations (along with the associated parking lots and process links) that were located along Howard and Braddock at the development location were deleted. The files were converted back to TRANSIMS network files via FileFormat. The finalized no-build

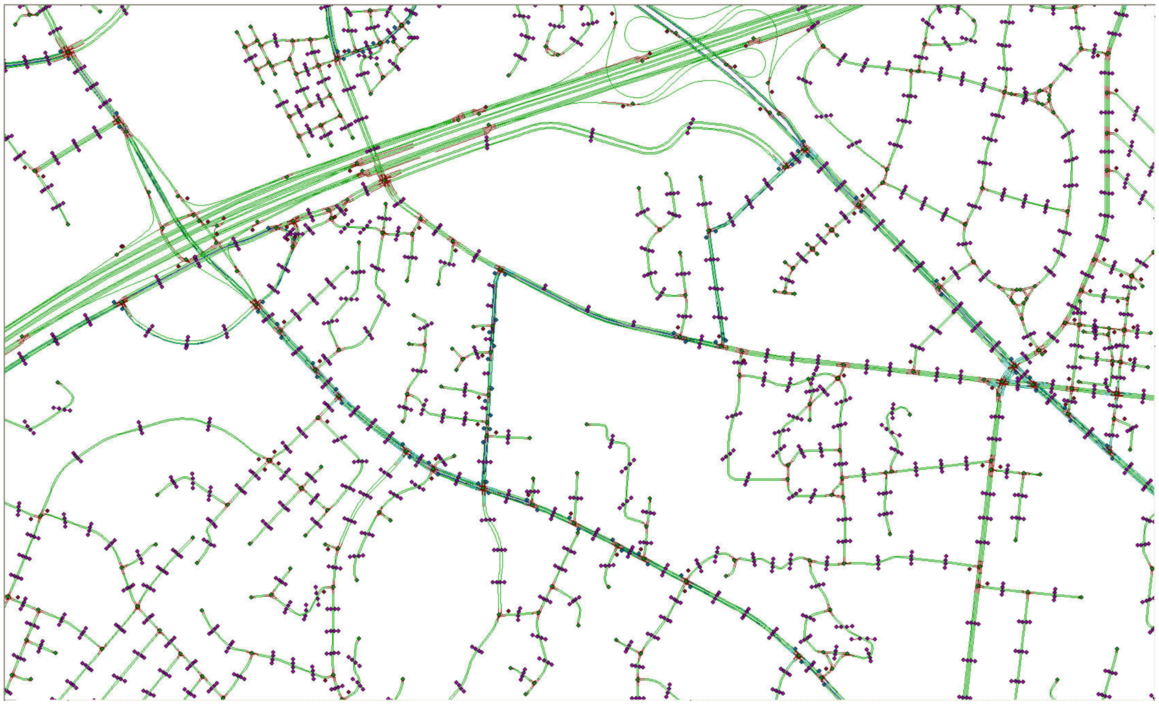

Figure 4: Edited No-Build Network

network is shown in Figure 4.

For the build scenario, the existing input node, link, and zone files were run through ArcNet and opened with a GIS editor. Figure 5 shows the existing network surrounding the new development.

4.5 No-Build Scenario

Determining the level of service for the no-build scenario is important for a DRI analysis to provide a comparison of the performance of the network without the development. In the ConvertTrips control file, the Trip_Scaling_Factor_# key should be specified for each trip table, corresponding to the growth factor between the year that the trip table data was collected and the build out year. This growth rate can be found by looking at the long range transportation plan for the region. If an annual growth rate is provided, the trip scaling factor is equal to e^{nr}, where n is the number of years between the trip table data collection year and the build out year, and r is

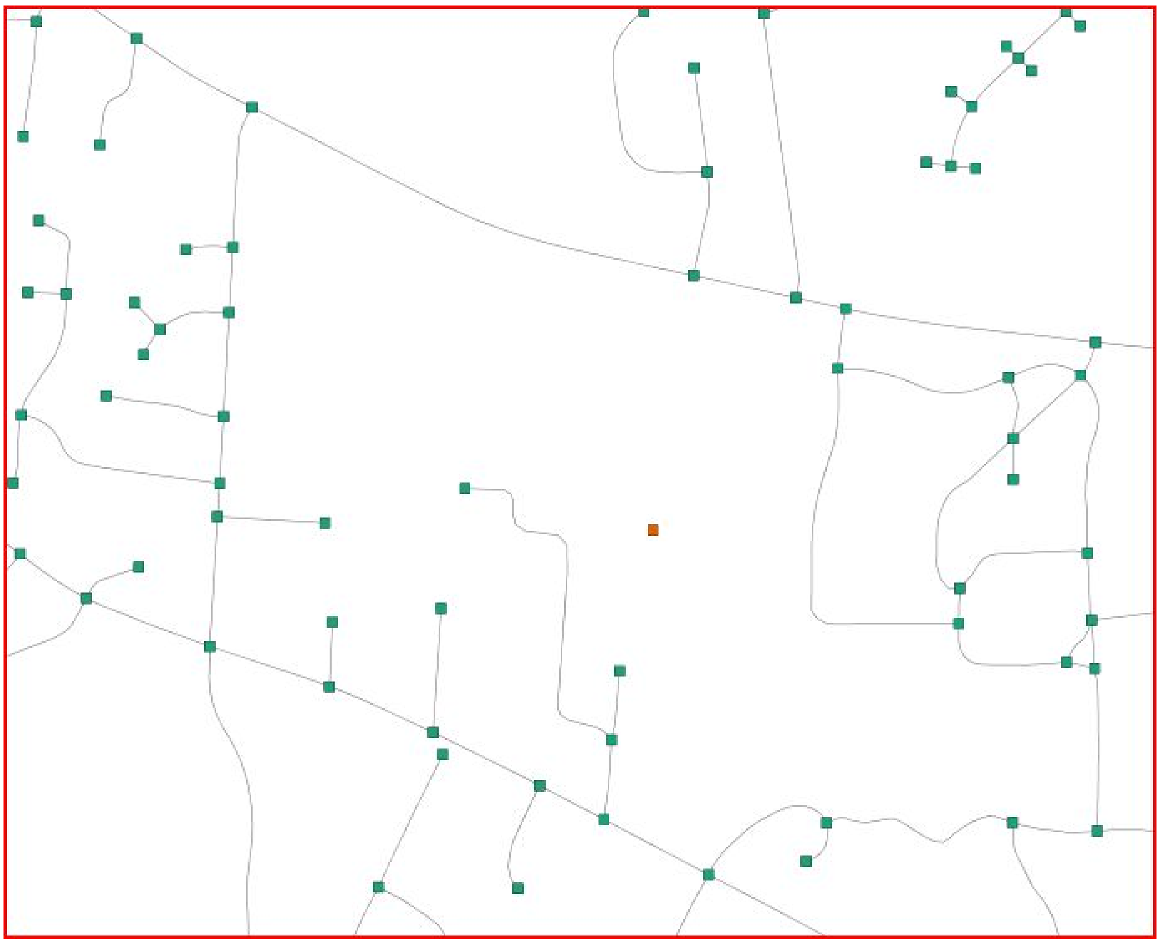

Figure 5: Input Files

Table 8: Level of Service for Links and Intersections

Level of Service	Link Density (pc/mi/ln)	Signalized Intersection Delay (sec/veh)	Unsignalized Intersection Delay (sec/veh)
A	0 - 11	0 - 10	0 - 10
B	> 11 - 18	> 10 - 20	> 10 - 15
C	> 18 - 26	> 20 - 35	> 15 - 25
D	> 26 - 35	> 35 - 55	> 25 - 35
E	> 35 - 45	> 55 - 80	> 35 - 50
F	> 45	> 80	> 50

the annual growth rate in decimal form. If a total percent growth is given, the trip scaling factor is equal to $1 + r$, where r is the overall growth rate in decimal form.

In order to save disk space with the runs, the only microsimulator outputs that need to be created are an Output Summary File for each peak hour. If the existing peak hour is known, the exact hour can be set using the Output_Summary_Time_Range key. If not, a two-hour period (such as 07:00..09:00) can be specified to capture the peak hour. The same thing can be done with the second Output Summary file to get data for the evening peak hour. Specifying exact links with the Output_Summary_Link_Range key can limit the printout to links in the area surrounding the DRI, and setting the Output_Summary_Turn_Flag key to TRUE will print out turning volumes and delays as well.

There is no set rule as to how many router and microsimulator feedback loops are needed to get the results to converge. A trial run of each regional network can be used to determine the number of loops needed to reach vehicle equilibrium.

The Output Summary file from the last microsimulator feedback loop can be used to evaluate the current level of service at the study intersections and links, according to the thresholds in Table 8.

4.6 Build Scenario

The build scenario that will be analyzed is the construction of a 200,000 square foot commercial shopping center. This shopping center will contain the following tenants, with store areas based on the size of a nearby shopping center as well as an approximation of the normal size of the store:

- 45,000 SF Home Improvement Superstore
- 30,000 SF Supermarket
- 20,000 SF Electronics Superstore
- 15,000 SF Arts and Crafts Store
- 5,000 SF Fast-Food Restaurant
- 85,000 SF Other Commercial - Shopping Center

The intersection of West Braddock Road and North Howard Street currently includes a large area that is undeveloped on the southeast corner, as seen in Figure 6.

4.7 DRI Network

Before the DRI can be analyzed, new roadways and activity locations must be added into the existing network files. As was done to ensure the network resembles the current roadway configuration, the network must be changed again to add new infrastructure from the DRI. New roadways, turning lanes, and traffic signals that are a part of the DRI must be added into the network. For proper trip routing for DRI's with parking lots, a link should be added for every driveway that leads to a parking lot, with all the driveway links ending at a central node in the development. At the central node, an extra link needs to be created, with a single parking location, process

Figure 6: Aerial of Study DRI Location, Source: Bing, Microsoft 2009

link, and activity location located on it, to represent the parking lot. For a residential development, TRANSIMS can be allowed to space activity locations equally over the roadways inside the development. The activity location(s) for the DRI should have a unique zone number that corresponds to the zone used in the trip tables. Once the new network is in place, the changes need to be converted back into TRANSIMS files using either FileFormat or GISNet.

For purposes of the case study, the new development is assumed to have three driveways- one on Howard, and two on Braddock. The existing roadway links were split at the location of each driveway, and nodes added for the new intersections. A link was created from each driveway node into the middle of the development. The driveway links meet at a central node, and there is an additional link from the central node into the development further. The activity location for the DRI will be located only on the additional link, so that the decision as to which driveway the vehicle uses is based on the links outside of the development that the vehicles utilizes, not which activity location the vehicle is assigned to inside the development. Before saving the changes to the shapefiles, the attribute files were updated to contain the coordinates and node number (node attributes), and the correct anode, bnode, distance of link, and link number (link attributes).

The input node and link files were converted back to TRANSIMS files using FileFormat. The network was run through TransimsNet, IntControl, and TransitNet before being converted back to shapefiles with ArcNet. However, there were errors with TRANSIMS processing the files created with FileFormat, so further network editing of the build scenario failed.

4.8 DRI Traffic Volumes

Before new volumes can be entered into the trip tables, the existing volume of trips in and out of the zone containing the DRI needs to be determined for the trip types that the DRI will effect (if the development is commercial only, home-based work trips do not need to be counted, etc.) From the existing volumes, the percentage of trips from each zone that end in the DRI zone (and vice-versa with the trips beginning in the DRI zone) can be calculated.

In order to determine the volume of vehicles expected to enter and exit the facility during the peak hours, the Institute of Transportation Engineers (ITE) Trip Generation Handbook should be used. Using the percentages calculated from the existing data, the new trips can be assigned as coming to and from other zones.

For the build scenario, according to the ITE Trip Generation Handbook, and assuming no pass-by trips, the new shopping center will create 15,575 new trips per day. The breakdown of trips is found in Table 9.[9] Of the 15,575 new trips, almost 8,000 trips occur during either the AM or PM Peak.

The original trip distribution was used for the no-build scenario. In order to create a reasonable estimate of the distribution of trips, the given trip tables were opened and all records containing zone 59 (as either the origin or the destination zone) were compiled. After summing the number of trips entering and exiting zone

Table 9: Trips by Land-Use

ITE Code	**Land Use**	**Total Daily Trip Generation**	**AM In**	**AM Out**	**AM Total**	**PM In**	**PM Out**	**PM Total**	**Total of Peak Periods**
860	Home Improvement Superstore	1,835	29	25	54	52	58	110	917
850	Supermarket	3,400	48	20	78	184	177	360	1,700
863	Electronics Superstore	901			6	44	46	90	450
879	Arts and Crafts Store	848				43	50	93	424
934	Fast Food Restaurant with Drive Thru	2,481	135	130	266	90	83	173	1,240
820	Shopping Center	6,110	87	55	142	270	292	562	3055
	Totals	**15,575**	**299**	**231**	**546**	**683**	**707**	**1,389**	**7,787**

59, the percentage of the total trips was calculated for each record. A copy of each record was made, and zone 59 changed to zone 63 for each record. The total number of trips expected due to the new development (15,575 based on the Trip Generation Handbook) was multiplied by the calculated percentage to create the number of daily trips between the two zones. The trips that were originally within zone 59 were divided in half so that half of the trips went from zone 59 to zone 63 and the other half went from zone 63 to zone 59, because the overall trip generation shows an equal number of trips in and out over the course of the day. No internal capture of trips was assumed in this analysis, resulting in zero trips from zone 63 to zone 63.

4.9 DRI Analysis

Once the new network and new traffic volumes are in place, the files should be run through ConvertTrips and the Router and Microsimulator loops again. The results files should be compared to the base case results to determine the impact the DRI will have on the roadway network. Any link that is severely impacted by the DRI needs to be improved, by adding lanes, turn-bays, or any other accepted method. Roadway improvements need to be added back into the network, and the model run again with the changes. This process can be repeated until the network operates at an approved level of service.

The process begins with ArcNet and FileFormat. These two modules can be run as many times as needed to make changes to the input files before continuing with the rest of the case study. After the inputs are edited, the rest of the network creation is run. Another chance at editing the network files occurs before ConvertTrips. Any changes made to the shapefiles must be converted back to TRANSIMS files with FileFormat before Convert Trips can be run. After the network creation and trip distribution are complete, the router runs begin. For the purposes of the case study, the router feedback loop is run five times. After the last PlanSelect, the microsimulator feedback loop begins. It too is run five times to an assumed convergent state. On the last loop, LinkSum is run after LinkDelay, ending the analysis.

The case study was abandoned after errors within TRANSIMS were encountered. Although FileFormat was designed for the sole purpose of converting shape files into TRANSIMS network files, future TRANSIMS modules found errors in the new files and were unable to read them. For the no-build scenario, this occurred at ConvertTrips, and the build scenario failed when running TransimsNet.

Throughout the attempted case study, it became apparent that TRANSIMS is not currently able to analyze new developments in a timely manner, without extensive understanding of control and batch files, as well as some of the finer points of how TRANSIMS functions.

4.10 Comparison of Current Methodology with TRANSIMS Methodology

Table 10 compares the steps to completing a traffic analysis using current methods with the proposed TRANSIMS methodology. Assuming that there is already a regional TRANSIMS module, TRANSIMS avoids a large portion of the data collection needed to set up the network and record existing volumes. However, many traffic analysis softwares automatically calculates the performance of the network as data is entered, instead of needing to run an analysis.

Table 10: Comparison of Current Methodology with TRANSIMS Methodology

Step	Current Method	TRANSIMS Method
(1) Collect roadway geometry and characteristics	Take field measurements and/or measure from aerial photographs	Take field measurements and/or measure from aerial photographs

Continued on next page

Table 10 – continued from previous page

Step	Current Method	TRANSIMS Method
(2) Collect traffic volumes and turning movement counts	Place count tubes on roadways and/or hand-count turning movements	Already exists in regional TRANSIMS network
(3) Create network in analysis software	Code network into analysis software	Run network modules and ensure that existing TRANSIMS network matches field observations
(4) Build exiting volumes to build-out year volumes	Multiply traffic counts by projected growth rate	Add growth factors to ConvertTrips control files
(5) Balance background traffic volumes	Ensure that volume into a segment is equal to volume out by hand	Not applicable to TRANSIMS
(6) Enter background volumes into analysis software	Code volumes into analysis software	Already in exists in regional Trip Tables
(7) Process no-build scenario	Completed during data entry	Run analysis modules
(8) Determine LOS of Intersections and Segments	Print reports containing performance measures	Convert results from analysis modules into level of service performance measures
(9) Create network with development infrastructure	Edit existing network to include additional infrastructure from the development	Edit TRANSIMS network to include DRI infrastructure
(10) Project developmental traffic volumes	Use the ITE Trip Generation Handbook	Use the ITE Trip Generation Handbook
(11) Add development volumes to background traffic	Add development traffic to the background traffic in model	Add development volumes into trip tables
(12) Process build scenario	Completed during data entry	Run analysis modules
(13) Determine LOS of Intersections and Segments	Print reports containing performance measures	Convert results from analysis modules into level of service performance measures

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Table 10 – continued from previous page

Step	Current Method	TRANSIMS Method
(14) Make network changes to mitigate losses in performance	Edit network elements in analysis software	Edit network elements in analysis software
(15) Process Improvements Scenario	Completed during data entry	Run analysis modules
(16) Determine LOS of Intersections and Segments	Print reports conataining HSM performance measures	Convert results from analysis modules into level of service performance measures
(17) Repeat Steps 14-16 until all losses are mitigated	See other steps	See other steps

4.11 Summary

The proposed TRANSIMS methodology is very similar to the existing DRI methodology. TRANSIMS functions as traffic analysis software in analyzing both the base case and build-out scenario. However, instead of having to distribute trips along the network by hand, TRANSIMS is able to distribute the trips based on the way drivers react to traffic.

Before the case study itself was even started, issues were identified with running TRANSIMS using a large region. Personal computers do not have the memory and processing capability to model a large TRANSIMS network in an acceptable period of time. While TRANSIMS is able to handle changes to the roadway infrastructure and number of trips, the process to make the changes is tedious. As seen in the case study, a small error within TRANSIMS can prevent an analysis from occurring.

CHAPTER V

FINDINGS AND RECOMMENDATIONS

5.1 Findings

5.1.1 Benefits of TRANSIMS

If the limitations of TRANSIMS can be overcome in the future, TRANSIMS has a chance to become a strong analysis tool that can be updated with all of the large developments being developed in a region. When all the Developments of Regional Impact (DRI) in a region are added into the network, the effect of multiple developments will be seen on the regional level much better.

The most significant advantage of using TRANSIMS over some other modeling software packages is that it takes into consideration the effect of the development on the background traffic, and not just the new build traffic. Figure 7 shows a sample network, with new development, to illustrate the ways that traffic could be influenced by a development. In the sample network, there are two routes that vehicles can take. Route A uses a direct path between the two major roadways, and the new development borders the connecting roadway. With Route B, the vehicles use a smaller, less direct neighborhood route to travel between the two major roadways.

In the situation where the roadways used in Route A are already congested, some of the traffic is most likely using Route B to save time. However, if the roadways on Route A are improved as part of the new development, the drivers using Route B may find that Route A is once again faster, and switch back to using Route A. There would be additional traffic on Route A that was not considered as part of the background traffic for the development.

Some of the current models could also over-count the background traffic in the

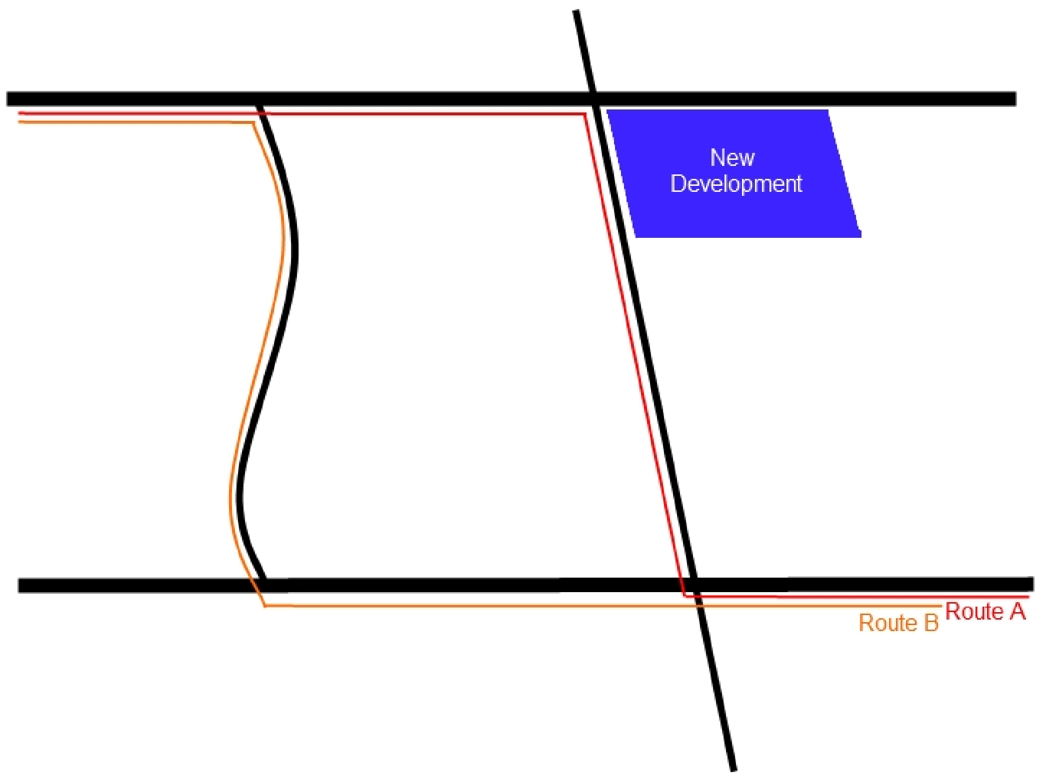

Figure 7: Possible Routes

build scenario if vehicles that use Route A begin using Route B to avoid the additional traffic that is a result of the new development and the traffic control devices that may be added due to the new development. Many times, new developments add enough additional traffic to significantly impact the travel time on the surrounding roadways. Drivers familiar with the area will learn where the additional traffic is located and choose an alternate route.

In both of the above situations, the background traffic, which is normally assumed to be constant between the no-build and build scenarios, changes based on the addition of a new development. The effect of a new development on background traffic varies based on the availability of alternate routes, the roadway characteristics of all possible routes, as well as the existing traffic on both roadways. The router and microsimulator feedback loops included in a TRANSIMS analysis include the routing decisions of the background traffic, as the router learns where congestion is located, and routes are adjusted based on congestion levels.

5.1.2 Limitations of TRANSIMS

5.1.2.1 Data Requirements

TRANSIMS requires a large amount of data to create even the basic network. Once the initial network creation is complete for a region, there is still a large amount of information needed to be maintained. Anytime changes are made to the actual roadway network, such as speed limits, turn bays, and signalization, the network must be updated to reflect the changes. This effort requires a high level of coordination between the regional agencies that manage the regional TRANSIMS network and all of the local agencies that make changes to the actual roadway infrastructure.

5.1.2.2 TRANSIMS Assumptions

The amount of data needed to run a simulation creates more issues. In TRANSIMS network creation, there are many values that are normally assumed. For example, in a model designed to analyze the regional distribution of traffic, exact signal timings do not have a big impact on the results. However, when comparing intersection delays with and without traffic from a development, as is necessary for a DRI analysis, signal timings can have a large impact on the delay seen. The number of parameters that can be set in each control file creates problems when trying to create new control and batch files for a network. It is difficult to determine which parameters need to be changed from tehir default values, and which values are specific to a particular model when creating new control files based off existing control files from another model.

5.1.2.3 Activity Locations

TRANSIMS determines its trip generation based on the number of trips from zone to zone. The exact number of vehicles that enter and exit the roadways at any point along the link are not important. The current TRANSIMS model includes activity locations at places where there is currently no development (such as in the area analyzed in the case study). The exact location where vehicles enter the roadway is not as important when looking at regional traffic patterns and delays as it is when determining the traffic patterns and delays on specific links and nodes.

5.1.2.4 Usability

One of the biggest issues that would prevent many traffic engineers from using TRANSIMS to analyze DRIs is the lack of a graphical user interface. Most practicing traffic engineers (who are not researching), do not know how to compile their own programs and write and operate batch and control files. While these items can appear easy to learn, engineering curriculum does not provide enough basic information for troubleshooting any issues that arise. Introductory computer science classes do not prepare an engineer for many of the challenges that TRANSIMS presents. Error messages in TRANSIMS are not easily understood or fixable without knowledge of programming concepts.

5.2 *Recommendations*

5.2.1 New TRANSIMS Modules

TRANSIMS was designed as a tool that can be customized for any application. As such, it is not currently equipped to handle some of the unique challenges that adding a development presents. The following additions to the TRANSIMS platform are presented as recommended improvements to TRANSIMS that would facilitate the use of TRANSIMS for DRIs.

5.2.1.1 Built-In GIS Tool

Editing a TRANSIMS network by adding to and modifying the network files themselves is nearly impossible. For even small networks, the size of the network files are too large to sort through and find the specific nodes and links that must be edited. The current TRANSIMS framework includes tools to export the network into shapefiles and convert shapefiles back into network files, allowing the files to be edited in any geographic information system (GIS) tool. However, the GIS editing only solves the issue of finding which record needs to be edited. The attributes of all of the new records still must be entered manually. TRANSIMS would benefit from having a built-in GIS tool that reads and writes directly to TRANSIMS network files.

With the exception of the node file, the attributes of every network file reference at least one other network element. Thus, changes to network elements affect more than the individual element. The GIS tool should alert the user when they edit a network element that is referenced by some other network element, so that there are no problems with cross-references between files.

Nodes are the most basic network file in TRANSIMS. Each record contains the node id, the x-, y-, and z-coordinates of the node, and a note that specifies whether the node is an external station or a network node. Thus, the GIS tool should place the nodes onto the network first, and base the locations of the remaining network elements off of the nodes. When a new node is added into the map, the GIS tool should record the coordinates of the node into the attributes of the record, as well as prompt the user to specify whether the node is an external station or network node.

Links have over twenty attributes for each record. The location of a link is based on the nodes on either end, and further refined with a setback and bearing from each node. The GIS tool should be able to divide existing links into two separate links (by asking the user to specify the distance from the ANODE to the split) and add new links onto the network. The GIS tool should automatically create a new node at the split, calculating the coordinates of the node based off of the coordinates of the original node's ANODE and BNODE. The tool should then change the BNODE of the existing link to the Node ID of the new node, and update the length of the node based on user input. The remaining attributes should remain the same, and be copied to a new link record, where the ANODE is the new node, the BNODE is the BNODE from the original link, and the length is the difference between the original link length and the other link length.

When the GIS tool is used to draw a new link on the network, the user should be able to draw a link between two nodes, or begin the link at an existing node and have the GIS tool create a new node for the BNODE. If the GIS tool must create a BNODE, the coordinates of the new node should be specified at the location where the link ends. While the length and bearings of the link can be calculated by the GIS data, the user should be prompted to add a name for the link, and the remaining attributes.

These recommendations do not cover all of the possibilities of a GIS tool, but are issues that are most helpful to DRI analyses.

5.2.1.2 ConvertTrip Changes

A major portion of a DRI analysis is adding additional traffic to the network. Existing trip tables offer information that can provide a realistic trip distribution, based on how people are already traveling around the region. However, integrating daily site traffic volumes into the existing trip tables is currently a tedious process. Instead of creating a separate module to handle the trip distribution, ConvertTrips could be modified to include a tool that automates the addition of DRI traffic to the existing traffic. Multiple DRIs can be added to the trip tables within the same ConvertTrips control file by repeating control keys, such as the ones listed below, with a new value of N.

- DRI_ZONE_N: The new zone number for the DRI. Each DRI needs to have its own, unique zone.

- DRI_DAILY_VOLUME_N: The total daily traffic for the development. The daily volume will still be calculated from the methods described in the Trip Generation Handbook.

- DRI_TRIPTABLE_N_#: The existing trip tables. Each trip table that needs to be edited needs to be specified with its own numbered control key (distinguished by increasing the # by 1 for each trip table).

- DRI_BASE_ZONE: The existing zone surrounding the DRI location. The base zone is the zone that the distribution of trips to the new zone will be formulated from.

Before ConvertTrips reads the existing trip tables, it should look at the control file to see if there are control keys specified for any DRIs. If a DRI is present, the specified existing trip tables should be read by ConvertTrips, and a new array of values should be created, containing all records that include the base zone as either the origin or destination zone and the trip table the record appears in. Wherever the base zone number appears in the array, the new zone number should replace the base zone number. The only exception to this replacement is when the origin and destination zones are both the base zone. In this case, an additional record should be created and trips split evenly between the two records. One record should have an origin of the base zone and a destination of the new zone and the other should have an origin of the new zone and a destination of the base zone. The sum of all existing trips should be calculated, and a column added into the array that is the percentage of trips represented by each record. In order to determine the number of trips for each record, the percentage calculated from the base zone records should be multiplied by the DRI Daily Volume, rounded to the nearest whole number, and placed in a new column in the array. The columns with the number of trips from the base zone and the percentage of trips for each record can then be deleted. The last step is for ConvertTrips to add each record back into the original trip table. This process should repeat for all of the DRIs in the control file, and then ConvertTrips can complete its trip assignment as it normally does.

5.2.1.3 Microsimulator Output Files

The most common ways of evaluating the performance of segments and intersections are by finding the level of service for that particular facility. To help facilitate the evaluation of DRI scenarios, additional output files that provide the Highway Capacity Manual level of service could be provided as an optional microsimulator output. The daily and peak-hour volume, , volume-to-capacity (v/c) ratio, speed, delay, and level of service should be provided for the specified segments and the daily and peak-hour volume, v/c ratio, delay, and level of service should be provided for the specified turning movements. For data manipulation purposes, the segments and turning movements should be in separate output files. These files should also be able to be converted into a shapefile for a graphical display of the network performance.

5.2.1.4 Graphical User Interface

In order to improve the usability of TRANSIMS, there should be a graphical user interface to assist in running the TRANSIMS modules. There are 90 control files used to run the Alexandria network. In order to create these 90 control files with the run set-up processes, there are still 32 master control files and 17 set-up control files that require editing. A graphical user interface could help with the set-up of the master control files by prompting the use for the keys that need to be designated, and filling in the control keys in all control files they apply to. A graphical user interface could also prompt the user as to the format of the key. Because TRANSIMS is open-source, changes to TRANSIMS happen quicker than help files and sample control files are produced. If all updates include updating a graphical user interface, knowing which control keys are needed for a module is automated for the user.

5.3 Summary

At this point in time, TRANSIMS is not equipped to analyze Developments of Regional Impact without significant effort and a thorough understanding of TRANSIMS, with emphasis on how all of the control, batch, and network files are interrelated. While theoretically, TRANSIMS should provide results that are more realistic than are currently produced, the limitations of TRANSIMS prevented results from being analyzed to test this theory. However, if additional TRANSIMS modules are developed that assist in the network creation, trip table creation, and analysis of results, TRANSIMS could become a strong tool for analyzing the impact of new developments on the roadway network.

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